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A CATALOG OF POSITIONS AND PROPER MOTIONS

OF 258 997 STARS FOR THE EPOCH AND EQUINOX OF 1950.0

by

the Staff of the

Smithsonian Astrophysical Observatory

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Cambridge, Massachusetts 02138

SAO Special Report No. 151

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INTRODUCTORY NOTE

This Special Report, which describes the preparation and contents
of the SAO Star Catalog, will also serve as the introduction to
the printed version of the Catalog. (See page 5 for a full de-
scription of the available forms of the Catalog.) We issue this
preliminary form of the Introduction to invite comments from inter-
ested persons.

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Abstract.--All available catalogs of high positional accuracy were used to compile a computer-accessible star catalog that would cover the entire sky. This report describes the preparation and contents of the SAO Star Catalog. Presented in the Catalog are positions and proper motions for about 259,000 stars, with an average distribution of 6 stars per square degree. The Catalog includes the following information for each star: right ascension and declination, standard deviations, mean epochs of the original observations, annual proper motions, visual magnitude, photographic magnitude, spectral type, Durchmusterung number, catalog used as source, and explanatory notes.

AUTHOR

Preface

In 1959, in the course of developing a system for tracking artificial earth satellites and reducing their positions as accurately as possible, the Smithsonian Astrophysical Observatory undertook to compile for its Photoreduction Division a computer-accessible star catalog that would cover the entire sky and give proper motions for all the stars listed. All available catalogs of high positional accuracy, whose data could be reduced to a homogeneous frame of reference,[1] were used. Catalogs that did not include proper motions were compared with other catalogs of earlier epoch to derive the necessary proper motions.

Since such an amalgamation of star positions would obviously be useful to other workers, in addition to those in the Photoreduction Division, the final catalog was made to include more complete information than that required for the reduction of satellite positions, and is here made available in printed form.

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[1] Originally that of the FK 3; later, that of the FK 4.

1. The Star Catalog

The Smithsonian Astrophysical Observatory Star Catalog results from the combination of several earlier catalogs: the FK 4, FK 3, GC, AGK 2, AGK 1, Greenwich AC, Yale, Cape, Cape Zone, Me 3, and Me 4.[2] The new compilation gives positions and proper motions for about 259,000 stars, having an average distribution of 6 stars per square degree. The star positions have an average standard deviation of $0\overset{''}{.}2$ at their original epochs ($0\overset{''}{.}5$ at epoch 1963.5). The equinox is 1950.0 and the system that of the FK 4.

The SAO catalog includes the following information for each star:

Right ascension (α_{1950}) and declination (δ_{1950}) for equator, equinox, and epoch 1950.0.

Standard deviation (σ) of the position at epoch 1950.0.

Right ascension (α_2) and declination (δ_2) for the equator and equinox 1950.0, at the mean epoch of the original observations (in seconds only).

Standard deviations (σ, σ') of α_2 and δ_2.

Mean epochs (t_2, t_2') of the original observations in right ascension and declination.

Annual proper motions for right ascension (μ) and declination (μ').

Standard deviations (σ) of μ and μ'.

Visual magnitude (for 99 percent of the stars).

Photographic magnitude (for 50 percent of the stars).

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[2] A complete list of the source catalogs, together with the abbreviations used to refer to them in this text, appears in section 5, page 16.

Spectral type (for 83 percent of the stars).

Durchmusterung number (BD, CD, CPD).

Catalog used as source.

Number of star as listed in source catalog.

Explanatory notes.

The SAO catalog is available in three forms:

1. Magnetic tapes compatible with IBM-729 tape units. Three sets of tapes exist: A) A set of two tapes in an eleven-word binary format, which presents all the information as given in the printed form (FK 4 system). B) A set of eight tapes in a nine-word binary format (FK 3 system only), which does not include the positions at epoch 1950.0. C) A set of twenty tapes in the original card-formats and the systems of the source catalogs.

2. The printed form given in this book, transcribed from the tapes in Set A.

3. A set of 156 star charts, 30" by 30", plotted and reproduced on a scale of 120"/mm at epoch 1950.0. The charts also include globular clusters, planetary nebulae, and external galaxies.

2. Methods of reduction

Systematic corrections.--Corrections were applied to the positions and proper motions given in all catalogs not already in the FK 4 system. The entries were first reduced without interpolation to the system of the GC by use of tables by Boss (1936) or, for the Yale catalogs, by Barney (1951). For reduction to the FK 3 system, Kopff's (1939) tables 4, 5, and 6 were applied. Tables "FK 4 - FK 3", published in the FK 4, were used for the final reduction to the FK 4 system, also without interpolation.

Two catalogs required further systematic corrections. As indicated in the Introduction to the Greenwich AC, entries in that catalog required a correction to the right ascensions dependent upon magnitude, and the proper motions for stars given in the Cape Zone required corrections depending upon right ascension, declination, and magnitude (Williams, 1947, table 3.11, cols. 2, 3, 4).

Precession--Stars from catalogs that were referred to an equinox other than that of 1950.0 were precessed to 1950.0 by use of Newcomb's constant and the rigorous formulas,

$$l_0 = \cos \alpha_0 \cos \delta_0 \, ,$$

$$m_0 = \sin \alpha_0 \cos \delta_0 \, , \qquad (1)$$

$$n_0 = \sin \delta_0 \, ,$$

where

α_0, δ_0 = right ascension and declination at equinox of the source catalog, epoch t_0 ,

l_0, m_0, n_0 = direction cosines referred to equinox of t_0 .

Setting up the matrix, we have:

$$
\begin{pmatrix} l \\ m \\ n \end{pmatrix} = \begin{pmatrix} \cos\varkappa\cos\omega\cos\upsilon - \sin\varkappa\sin\omega & -\sin\varkappa\cos\omega\cos\upsilon - \cos\varkappa\sin\omega & -\cos\omega\sin\upsilon \\ \cos\varkappa\sin\omega\cos\upsilon + \sin\varkappa\cos\omega & -\sin\varkappa\sin\omega\cos\upsilon + \cos\varkappa\cos\omega & -\sin\omega\sin\upsilon \\ \cos\varkappa\sin\upsilon & -\sin\varkappa\sin\upsilon & \cos\upsilon \end{pmatrix} \cdot \begin{pmatrix} l_0 \\ m_0 \\ n_0 \end{pmatrix} \qquad (2)
$$

where

l, m, n = direction cosines referred to the equinox of 1950.0,

$\varkappa$, ω, υ = angles given by the expressions:

$$\varkappa = (23042\overset{..}{.}53 + 139\overset{..}{.}73\tau + 0\overset{..}{.}06\tau^2)T + (30\overset{..}{.}23 - 0\overset{..}{.}27\tau)T^2 +$$
$$18\overset{..}{.}00\ T^3,$$

$$\omega = \varkappa + (79\overset{..}{.}27 + 0\overset{..}{.}66\tau)T^2 + 0\overset{..}{.}32\ T^3,$$

$$\upsilon = (20046\overset{..}{.}85 - 85\overset{..}{.}33\tau - 0\overset{..}{.}37\tau^2)T + (-42\overset{..}{.}67 - 0\overset{..}{.}37\tau)T^2$$
$$- 41\overset{..}{.}80\ T^3,$$

(3)

in which

$$\tau = \frac{t_0 - 1900.0}{1000.0}\ , \qquad\qquad T = \frac{1950.0 - t_0}{1000.0}\ ,$$

and t_0 = epoch of original equinox in tropical years.

The positions at equinox 1950 are given by the relations

$$\alpha = \arctan \frac{m}{l}$$

(4)

$$\delta = \arcsin n\ .$$

For a more complete discussion of precession, see the explanatory supplement to the ephemeris (Nautical Almanac, 1961) where the angles $\varkappa$, ω, υ, just defined, are represented by ζ_0, z, θ, respectively.

Standard deviations of position--Standard deviations (standard errors) of positions cited in the source catalogs, either for each individual star or for all the stars listed, were used directly. Some catalogs gave probable errors (r), which were converted to standard deviations by the formula,

$$\sigma = \frac{3}{2}\ r\ .$$

Some catalogs gave no standard deviations. However, when weights assigned according to the number of observations in each coordinate were available in the GC (for meridian catalogs), the standard deviations were derived by use of the relations,

$$\sigma = \frac{0\rlap{.}''45}{\sqrt{w}} , \qquad \sigma' = \frac{0\rlap{.}''45}{\sqrt{w'}} , \qquad (5)$$

where w and w' are the weights for right ascension and declination, respectively, and $0\rlap{.}''45$ is the standard deviation of unit weight, as given in the GC.

Standard deviations of positions in the AGK 2 were computed as recommended in that catalog.

All standard deviations in the SAO catalog are expressed in seconds of great circle arc.

Proper motions--Proper motions for AGK 2 stars were computed by comparing the AGK 2 positions (in the FK 3 system) with early epoch positions from either the AGK 1 or the Greenwich AC (in the FK 3 system), after identity of the stars had been determined by a series of tests on positions, BD numbers, and magnitudes. The following formulas were used:

$$\mu = \frac{\alpha_2 - \alpha_1}{t_2 - t_1} ,$$

$$\mu' = \frac{\delta_2 - \delta_1}{t_2 - t_1} , \qquad (6)$$

where μ , μ' are the proper motions in right ascension and declination, and subscripts 1 and 2 refer to earlier and later epochs.

If two stars at t_1 or t_2 had the same BD number, the star for which the sum

$$(\alpha_2 - \alpha_1)^2 + (\delta_2 - \delta_1)^2 \qquad (7)$$

had the lowest value was used. When such a choice has been made, the fact is indicated in the catalog notes. When more than three stars at either t_1 or t_2 fulfilled all requirements for identification, the stars were omitted. Proper motions were computed for approximately 56,000 stars in the AGK 2.

When proper motions in right ascension were given in seconds of great circle arc, they were converted to seconds of time, by multiplication by the term sec $\delta/15$.

<u>Standard deviations of proper motion</u>-- Standard deviations for both μ and μ' are given in seconds of arc, in units of ".001. In general, the source catalogs gave the standard deviation (or probable error) of the components of the proper motion for every star. Some catalogs gave only one value applying to all proper motions included.

When proper motions were computed at SAO, their standard deviations were computed from the standard deviations of the two positions:

$$\sigma_\mu = \left(\frac{\sigma_2^2 + \sigma_1^2}{t_2 - t_1} \right)^{\frac{1}{2}} \qquad ,$$

$$\qquad\qquad\qquad\qquad\qquad\qquad (8)$$

$$\sigma_{\mu'} = \left(\frac{\sigma_2'^2 + \sigma_1'^2}{t_2 - t_1} \right)^{\frac{1}{2}} \qquad .$$

Supplementary information--Magnitudes, spectral types, and star numbers given in the source catalog are included in the SAO catalog with explanatory notes citing the specific origin of each one. Source catalog entries indicating double or variable stars have also been incorporated in the explanatory notes. About 36,000 spectral types from the HD were added to the zones covered by the AGK 2, and Durchmusterung numbers were added to stars in the GC and the FK 4.

Duplicate entries--When a star was listed in more than one source catalog, the duplicates were removed from the SAO catalog, insofar as this was possible. Stars were considered as duplicates when all of the following were true: their positions, at the common epoch of 1900.0, agreed within $10''.0$ in both coordinates; they had identical DM numbers; their visual magnitudes did not differ by more than $3^m.0$; they came from different catalogs; they were not noted as members of a double system.

When duplication occurred, the entry retained was that appearing first in the following list of catalogs: FK 4; FK 3; GC; Cape volumes 20, 19, 18, 17; Yale volumes 27, 26 II, 26 I, 25, 24, 22 II, 22 I, 21, 20, 19, 18, 17, 16, 14, 13 II, 13 I, 12 II, 12 I, 11; AGK 2 volumes 8, 7, 6, 5, 2, 1; Cape Zone; Me 4; Me 3.

Positions and standard deviations at 1950.0--Right ascension and declination at epoch 1950.0 are given by the equations

$$\alpha_{1950} = \alpha_2 + \mu \ (1950.0 - t_2) \quad ,$$

$$\delta_{1950} = \delta_2 + \mu'(1950.0 - t_2') \quad .$$

(9)

Since the standard deviations in α and δ were very close, if not identical, the positional uncertainty at 1950.0 is indicated by a single number, given by the formula,

$$\sigma_{1950} = \left[\frac{(\sigma)^2 + \{\sigma_\mu(1950.0 - t_2)\}^2 + (\sigma')^2 + \{\sigma_{\mu'}(1950.0 - t_2')\}^2}{2} \right]^{\frac{1}{2}} \quad . \quad (10)$$

Numbering system and order--For the tapes of general interest and for the printed version of the catalog, the stars at epoch 1950.0 were sorted by right ascension within 10-degree bands of declination and were numbered consecutively. Some statistical data were tabulated from the listing, and those of general interest are presented in figures 1 to 4.

3. Source catalogs

Where treatment of a catalog (or set of catalogs) deviated from the reduction procedures described earlier, the differences are explained below. Each of the following three catalogs covered the entire sky fairly uniformly.

FK 4--The FK 4 is the fundamental catalog for the reference system adopted for the SAO star catalog. The FK 4 lists centennial values for proper motions and their standard deviations, for which the SAO catalog gives the annual values. Standard deviations for α and μ were converted to seconds of arc.

FK 3--The SAO catalog lists annual rather than centennial values for proper motions and their standard deviations obtained from the FK 3. Standard deviations for α and μ were converted to seconds of arc.

GC--Probable errors (r) as given in the GC for positions and proper motions were converted to standard deviations. The U. S. Naval Observatory, from which we obtained the cards for this catalog, had added the DM numbers to all stars.

Cape--The four volumes of this catalog for the southern sky were used to cover the zones from -30° to -40° and from -52° to -64°. Although the Cape catalog contained between 40,000 and 50,000 stars, about 15 percent were omitted from the SAO catalog because their proper motions were not given. Standard deviations of position and proper motion (generally the same for all stars in a given volume) were set as shown in table 1.

Yale--The Yale catalogs were used for the sky zones from $+30^{\circ}$ to -30°, from $+50^{\circ}$ to $+60^{\circ}$, and from $+85^{\circ}$ to the pole. These zones together contained the largest number of stars taken from any one group of catalogs. In processing Yale volume 26 I (north pole), in order to obtain visual magnitudes it was necessary to omit the photographic magnitudes published in the original catalog. Standard deviations of position were set as shown in table 2.

Probable errors in proper motion, when given separately for each star, were converted to standard deviations. For 6 catalogs, in which standard deviation was not given for each star, the values for σ_{μ} and σ_{μ}' shown in table 3 were used.

AGK 2--Positions obtained from six volumes of the AGK 2 were used for those parts of the sky in the northern hemisphere ($+30^\circ$ to $+50^\circ$, and $+60^\circ$ to $+85^\circ$) not covered by a Yale catalog. No AGK 2 volume provided proper motions, spectral types, or visual magnitudes. After reduction to the FK 3 system, proper motions were derived by comparison with the appropriate zones of the AGK 1 or with the Greenwich AC. Visual magnitudes were taken from the early epoch catalogs used in the derivation of the proper motions, and spectral types were added to as many stars as possible from the Henry Draper Catalogue. Standard deviations for the positions were computed (Schorr, 1951; Kohlschütter, 1957; Heckmann, 1955) by the formula

$$\sigma = \sigma' = \left[((m_{pg} - 9\overset{m}{.}12)^2 \overset{''}{.}0061 + \overset{''}{.}145)^2 + \overset{''}{.}0036 \right]^{\frac{1}{2}} . \quad (11)$$

Cape Zone--Stars from the Zone Catalogue of 20,843 Stars, 1900 were used for the area from -40° to -52° to bridge the gap between the adjoining volumes of the Cape Annals. Photographic magnitudes, spectral types, and proper motions were added from the Proper Motions of Stars in the Zone Catalogue of 20,843 Stars, 1900. Positions were precessed to equinox 1950.0. Boss's weights were used to compute standard deviation in position for each star. The standard deviation of each component of the proper motion was set at $\overset{''}{.}012$ throughout.

Me 3 and Me 4--These two small catalogs were used to cover the
sky from -64° to the South Pole; the microfilm of the Me 4 was made
available to us by the Melbourne Observatory. The GC tables for these
catalogs included no corrections for μ or μ'; this lack may be a source
of systematic error for stars taken from these catalogs. The positions
at the early equinoxes of these catalogs (1890 and 1900) were precessed to
1950. Proper motions for Me 3 stars, given in Appendix I of Me 4, were
used in preference to Me 3 proper motions. If only one component of
a proper motion was given, the star was omitted. Standard deviations
for the positions were computed with Boss's weights. Standard devia-
tions for the proper motions in Me 3 were set at (σ_μ) ".033, $(\sigma_{\mu'})$ ".043;
and in Me 4 at (σ_μ) ".025, $(\sigma_{\mu'})$ ".036 .

AGK 1--Several volumes of the AGK 1 were used for comparison with
the AGK 2 in deriving proper motions, as described earlier. Mönnichmeyer's
(1909) corrections were used for all Bonn observations. Positions were
precessed to 1950, and standard deviations were computed with Boss's weights.

Greenwich AC--This catalog was used for comparison with the AGK 2 to
derive proper motions for stars in regions (+80° to +85°) not covered by
any volume of AGK 1. "The GC tables, which were used for the Greenwich AC,
were those for the Greenwich Second Nine-Year Catalogue, 1900, since both Green-
wich catalogs used the same reference stars." Dyson's introduction to the
Greenwich AC provided the magnitude equation used. Positions were precessed
to equinox 1950.0 and standard deviations of the positions were set at
".24 in both coordinates.

4. Statistical summary

The SAO catalog lists a total of 258 997 stars, of which 8,712 are double and 499 are variable.

A brief statistical summary of the data is presented in table 4 and figures 1 through 4.

5. Bibliographical sources

The chief sources used for the SAO catalog are listed under the abbreviated titles by which they are referred to in the text:

AGK 1

Doubiago, D.

    1898. Catalog der Astronomischen Gesellschaft, No. 1, Zone $+75^{\circ}$ bis $+80^{\circ}$, Kasan Sternwarte.

Courvoisier, L.

    1910. Katalog der Astronomischen Gesellschaft, No. 2. Zone $+70^{\circ}$ bis $+75^{\circ}$, Berlin Sternwarte.

Fearnley, C., and Geelmuyden, H.

    1890. Catalog der Astronomischen Gesellschaft, No. 3. Zone $+65^{\circ}$ bis $+70^{\circ}$, Christiania Sternwarte.

Krüger, A.

    1890. Catalog der Astronomischen Gesellschaft, No. 4. Zone $+55^{\circ}$ bis $+65^{\circ}$, Helsingfors und Gotha Sternwarten.

Deichmüller, F.

    1894. Catalog der Astronomischen Gesellschaft, No. 6. Zone $+40^{\circ}$ bis $+50^{\circ}$, Bonn Sternwarte.

Engström, F., and Psilander, A. A.

    1902. Catalog der Astronomischen Gesellschaft, No. 7. Zone $+35^{\circ}$ bis $+40^{\circ}$, Lund Sternwarte.

Wilterdink, J. H.

    1902. Catalog der Astromischen Gesellschaft, No. 8. Zone $+30^{\circ}$ bis $+35^{\circ}$, Leiden Sternwarte.

AGK 2

Schorr, R., and Kohlschütter, A.

    1951 - 1953. Zweiter Katalog der Astronomischen Gesellschaft

        für das Äquinoktium 1950. Vol. 1, $+70^\circ$ bis $+90^\circ$; vol. 2,

        $+60^\circ$ bis $+70^\circ$; vol. 5, $+45^\circ$ bis $+50^\circ$; vol. 6, $+40^\circ$ bis $+45^\circ$;

        vol. 7, $+35^\circ$ bis $+40^\circ$; vol. 8, $+30^\circ$ bis $+35^\circ$.

BD

Argelander, F.

    1859 - 1862. Bonner Durchmusterung, Sec. 1-3. Astron. Beob.

        Sternwarte Königl. Rhein. Friedrich-Wilhelms-Univ. Bonn,

        vols. 3, 4, 5.

Schönfeld, E.

    1886. Bonner Durchmusterung, Sec. 4. Astron. Beob. Sternwarte

        Königl. Rhein. Friedrich-Wilhelms-Univ. Bonn, vol. 8.

Cape

Jackson, J., and Stoy, R. H.

    1954 - 1958. Cape Photographic Catalogue for 1950.0. Ann. Cape

        Obs. Vol. 17, -30° to -35°; vol. 18, -35° to -40°; vol. 19,

        -52° to -56°; vol. 20, -56° to -64°.

Cape Zone

Gill, D., and Hough, S. S.

    1923. Zone Catalogue of 20,843 Stars, Equinox 1900.

Spencer Jones, H., and Jackson, J.

    1936. Proper Motions of Stars in the Zone Catalogue of 20,843 Stars,

        1900.

CD

Thome, J. M.

    1892 - 1913. Cordoba Durchmusterung, Parts I - IV. Resultados Obs.

        Nacional Argentino, vols. 16, 17, 18, 21.

Perrine, C. D.

    1932. Cordoba Durchmusterung, Part V. Resultados Obs. Nacional

        Argentino, vol. 21.

CPD

Gill, D., and Kapteyn, J. C.

    1896 - 1900. Cape Photographic Durchmusterung, Parts I - III. Annals

        Cape Obs., vols. 3, 4, 5.

FK 3

Kopff, A.

    1937 - 1938. Dritter Fundamentalkatalog des Berliner Astronomischen

        Jahrbuchs. Part I, Die Auwers-Sterne für die Epochen 1925 und

        1950, Veröff Astron. Rechen-Inst., No. 54. Part II, Die Zusatsterne

        für die Epoche 1950 , Preussischen Akad. Wiss., Phys.-math. Kl.,

        No. 3.

FK 4

Fricke, W., and Kopff, A.

    1963. Fourth Fundamental Catalogue. Veröff. Astron. Rechen-Inst.

        Heidelberg, No. 10.

GC

Boss, B.

    1936. General Catalogue of 33342 Stars for the Epoch 1950, vols.

       2 - 5. Carnegie Inst. Publ. No. 468.

Greenwich AC

Dyson, F. W.

    1914. Astrographic Catalogue 1900.0. Greenwich Section, vol. 3,

       $+64^{\circ}$ to $+90^{\circ}$.

HD

Cannon, A. J., and Pickering, E. C.

    1918 - 1924. The Henry Draper Catalogue. Ann. Obs. Harvard Coll.,

       vols. 91 - 99.

Me 3

Baracchi, P., and Ellery, R. L. J.

    1917. Third Melbourne General Catalogue of 3068 Stars for the

       Equinox 1890.

Me 4

    1959. Fourth Melbourne General Catalogue, Reduced without Proper

       Motion to the Equinox 1900.0. (Microfilm.)

Yale

Schlesinger, F., and Barney, I.

    1939. Catalogue of 8101 Stars, -10° to -14° . Trans. Astron. Obs.

       Yale Univ., vol. 11.

1940. Catalogue of the Positions and Proper Motions of 8563 Stars,
-14° to -18° . Trans. Astron. Obs. Yale Univ., vol. 12, Part I.

1940. Catalogue of the Positions and Proper Motions of 4553 Stars,
-18° to -20°. Trans. Astron. Obs. Yale Univ., vol. 12, Part II.

1943. Catalogue of the Positions and Proper Motions of 4292 Stars,
-20° to -22°, Trans. Astron. Obs. Yale Univ., vol. 13, Part I.

1943. Catalogue of the Positions and Proper Motions of 9455 Stars,
-27° to -30°, Trans. Astron. Obs. Yale Univ., vol. 13, Part II.

1943. Catalogue of the Positions and Proper Motions of 15110 Stars,
-22° to -27°. Trans. Astron. Obs. Yale Univ., vol. 14.

Barney, I.

1945. Catalogue of the Positions and Proper Motions of 8248 Stars,
-6° to -10°. Trans. Astron. Obs. Yale Univ., vol. 16.

1945. Catalogue of the Positions and Proper Motions of 8108 Stars,
-2° to -6°. Trans. Astron. Obs. Yale Univ., vol. 17.

1947. Catalogue of the Positions and Proper Motions of 9092 Stars,
+15° to +20°. Trans. Astron. Obs. Yale Univ., vol. 18.

1948. Catalogue of 8967 Stars, +10° to +15°. Trans. Astron.
Obs. Yale Univ., vol. 19.

1949. Catalogue of the Positions and Proper Motions of 7996 Stars,
+1° to +5°. Trans. Astron. Obs. Yale Univ., vol. 20.

1950. Catalogue of the Positions and Proper Motions of 5583 Stars,
-2° to +1°. Trans. Astron. Obs. Yale Univ., vol. 21.

1950. Catalogue of the Positions and Proper Motions of 9060 Stars,
+5° to +9°. Trans. Astron. Obs. Yale Univ., vol. 22, Part I.

1950. Catalogue of the Positions and Proper Motions of 1904 Stars, +9° to +10°. Trans. Astron. Obs. Yale Univ., vol. 22, Part II.

1953. Revised Catalogue of 10358 Stars, +25° to +30°. Trans. Astron. Obs. Yale Univ., vol. 24.

1954. Revised Catalogue of 8703 Stars, +20° to +25°. Trans Astron. Obs. Yale Univ., vol. 25.

Barney, I., and van Woerkom, A. J. J.

1954. Catalogue of 1031 Stars, +85° to +90°. Trans. Astron. Obs. Yale Univ., vol. 26, Part I.

Barney, I., Hoffleit, D., and Jones, R.

1959. Catalogue of 8380 Stars, +50° to +55°. Trans. Astron. Obs. Yale Univ., vol. 26, Part II.

1959. Catalogue of 8164 Stars, +55° to +60°. Trans. Astron. Obs. Yale Univ., vol. 27.

Supplementary references

Barney, I.

1951. Supplementary Volume to the Yale Zone Catalogues, -30° to +30°. Trans. Astron. Obs. Yale Univ., vol. 23.

Boss, B.

1936. General Catalogue of 33342 Stars for the Epoch 1950. Vol. 1, Appendix III, pp. 165-339. Carnegie Inst. Publ. No. 468.

Heckmann, O.

1955. Correction to magnitude equation published in AGK 2, vol. 1. Personal communication.

Kohlschütter, A.

> 1957. Bericht über die im Bonner Anteil des AGK 2 verwendeten
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> Methoden. Introduction to AGK 2, vol. 11.

Kopff, A.

> 1939. **Vergleich des FK 3 mit dem General Catalogue von B. Boss.**
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> Astron. Nachr. vol. 269, pp. 160-167.

Mönnichmeyer, C.

> 1909. Verbesserte Örter des A. G. K. Bonn. Veröff. Königlichen
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> Sternwarte Bonn, No. 9.

Nautical Almanac

> 1961. Explanatory Supplement to the Astronomical Ephemeris and the
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> American Ephemeris and Nautical Almanac. Nautical Almanac
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> Office of the U. K. and the U. S. A.

Schilt, J., and Hill, S. J.

> 1937. Photographic magnitudes of 6902 Stars in the Zone $+55^{\circ}$ to
>
> $+60^{\circ}$. Contr. Rutherfurd Obs. Columbia Univ., No. 30, 32 pp.
>
> 1938. Photographic Magnitudes of 7280 Stars in the Zone $+50^{\circ}$ to
>
> $+55^{\circ}$. Contr. Rutherfurd Obs. Columbia Univ., No. 31, 36 pp.

Schorr, R.

> 1951. Introduction to AGK 2, vol. 1.

Williams, E. T. R.

> 1947. An Investigation of Stellar Motions, part III. Astron.
>
> Journ., vol. 53, pp. 58-63.

Errata--In addition to the errata listed in the catalogs themselves, corrections from the following sources were also incorporated in the SAO catalog:

Abetti, A.

>   1900. Cometa 1900 II, Footnote to Star 19. Astron. Nachr.,
>   vol. 154, pp. 62-63.

Barney, I.

>   1948. Corrections to the Albany General Catalogue. Astron. Journ.,
>   vol. 54, pp. 154-155.

Courvoisier, L.

>   1911. Berichtigungen zum Katalog der Astronomischen Gesellschaft,
>   Zone +70° bis +75°, Berlin. Astron. Nachr., vol. 187, pp. 159-160.

Doubiago, D.

>   1913. Positions corrigées du Catalogue A. G. Kasan. Astron. Nachr.,
>   vol. 196, pp. 321-322.

Duncombe, J. S.

>   1961. Personal communication.

Ebell, M.

>   1903. Notiz betr. AG. Helsingfors 7016. Astron. Nachr., vol. 164,
>   p. 155.

Graff, K.

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6. The columns in the SAO catalog

All positions and proper motions are given in the FK 4 system, referred to the equinox of 1950.0. The stars are listed in order of right ascension at epoch 1950.0, within ten-degree bands of declination from $+90^{\circ}$ to -90°. The various columns present the following information:

Column 1: A sequential number for reference, to be added to the large number at the top of the columns.

Column 2: Photographic magnitude and source.

Column 3: Visual magnitude and source.

Column 4: Right ascension for equator, equinox, and epoch 1950.0.

Column 5: Proper motion in right ascension (μ), expressed in seconds of time per annum in units of $0\overset{s}{.}0001$.

Column 6: Standard deviation of μ expressed in seconds of arc per annum in units of $\overset{"}{.}001$.

Column 7: Declination for equator, equinox, and epoch 1950.0.

Column 8: Proper motion in declination (μ'), expressed in seconds of arc per annum in units of $\overset{"}{.}001$.

Column 9: Standard deviation in μ' expressed in seconds of arc per annum in units of $\overset{"}{.}001$.

Column 10: Standard deviation of position at epoch 1950.0, in units of $0\overset{"}{.}01$.

Column 11: Seconds of right ascension at original epoch (α_2).

Column 12: Standard deviation of α_2, in units of $\overset{"}{.}01$.

Column 13: Epoch of α_2, in years, the initial digits (18.., 19..) being omitted. All epochs lie between 1875 and 1955.

Column 14: Seconds of declination at original epoch (δ_2).

Column 15: Standard deviation of δ_2, in units of $\overset{\prime\prime}{.}01$.

Column 16: Epoch of δ_2, in years, the initial digits (18.., 19..) being omitted. All epochs lie between 1875 and 1955.

Column 17: Spectral type and source.

Column 18: Source catalog (see table 5).

Column 19: Star number in source catalog and notes indicating double or variable stars.

Column 20: Notes to indicate source of Durchmusterung number, and presence of footnotes in the source catalog.

Column 21: DM number (column 20 should always be referred to when using DM numbers.)

The symbols used in the individual columns have the meanings given in the following tabulation.

Column 2, source of photographic magnitude

Code symbol	Source
blank	Source catalog
U	Unspecified
P	CPD
E	"Magnitude of Stars in Cape Zone"
H	Henry Draper Catalogue
G	General Catalogue
K	AGK 2
I	Introduction to source catalog
S	Schilt and Hill (1937, 1938).

Column 3, source of visual magnitude

Code symbol		Source
Visual	Photovisual	
blank	W	Source catalog
*	X	Source catalog or footnote in source catalog
I	Y	Introduction to source catalog
U	F	Unspecified
B		BD
C		CD
P		CPD
Q		Durchmusterung magnitudes and visual estimates
A		AGK 1
R		Cordoba Zones ("Resultados")
O		Cordoba Publications
Z		CGA or Cordoba Zones
L		Harvard publications, prior to 1920
T		Harvard photometry or measured at San Luis, Argentina (GC)
H		Henry Draper Catalogue
M		Combined magnitudes of component stars
N		Arithmetic mean of the maximum and minimum magnitudes of a variable star

Column 5, source of proper motions

Code symbol	Source
blank	Source catalog
Q	Comparison of source catalog and Greenwich AC
A	Comparison of source catalog and AGK 1
T	Comparison of source catalog and Greenwich AC on the basis of the smallest difference in positions
Y	Comparison of source catalog with AGK 1 on the basis of the smallest difference in positions

Column 17, source of spectral type[3]

blank	Henry Draper Catalogue
J	HD or classified by A. Cannon
L	G. G. Cillie
F	V. Goedicke
O	D. Hoffleit
M	M. W. Mayall
R	Leander McCormick Observatory
U	J. J. Nassau and C. K. Seyfert

Column 18, the source catalog. An explanation of the code symbols appears in table 5.

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[3]When the symbol "+++" appears, the spectrum was either composite, varying, or peculiar.

Column 19, double and variable stars

Code symbol	Meaning and source
D	Double star; see source catalog for source, usually Innes' catalog of southern double stars
K	Double star; Aitken's double star catalog
N	Double star; Burnham's double star catalog
V	Variable star (visual magnitude)
X	Variable star (photographic magnitude)
Y	Variable star (visual and photographic magnitude)
DV	Double and variable star.

Column 20, source of star numbers and existence of footnotes in the source catalog.

Code symbol		Source
Star number	With footnote	
blank	*	Source catalog only
blank	B*	Source catalog and BD
C	C*	Source catalog and CD
P	P*	Source catalog and CPD
J	J*	Cordoba B and CD
E	E*	Cordoba A and CD
A	A*	AGK 1 and BD
G	G*	GC and BD
W	W*	Cordoba B and CPD
X	X*	Cordoba A and CPD

Acknowledgments

Table 1.--Standard deviations of positions and proper motions for Cape catalog

Cape vol.	Position				Proper motion			
	σ		σ'		σ_μ		σ_μ'	
	Stars	Bright stars*	Stars	Bright stars*	Stars	Bright stars*	Stars	Bright stars*
17	"22		"21		"021		"021	
18	.15	.28	.21	.22	**	.01	**	.01
19	.15	.28	.18	.21	**	.01	**	.01
20	.14	.15	.14	.18	**	.01	**	.01

* Too bright to be measured on the photographic plates, but observed with a transit circle.

** Given separately for each star in the source catalog.

Table 2.—Standard deviations of positions for Yale catalog

Yale vol.	σ	σ'	Yale vol.	σ	σ'
11	ʺ180	ʺ158	19	ʺ173	ʺ173
12 I	.180	.158	20	.173	.173
12 II	.180	.158	21	.173	.173
13 I	.158	.158	22 I	.173	.173
13 II	.158	.158	22 II	.173	.173
14	.158	.158	24	.143	.143
16	.158	.158	25	.143	.143
17	.158	.158	26 I	.128	.128
18	.173	.173	26 II	.135	.135
			27	.135	.135

Table 3.--Standard deviations

of proper motions for Yale catalog

Yale vol.	σ_μ	$\sigma_{\mu'}$
21	$.''014$	$.''020$
24	.010	.008
	.015*	.010*
25	.005	.005
	.008*	.008*
26 I	.006	.006
	.009*	.009*
26 II	.007	.007
	.008**	.008**
	.009***	.009***
27	.007	.007
	.008**	.008**
	.009***	.009***

* For proper motions derived from only two positions.

** When two earlier positions were used, one from AGK 1.

*** When two earlier positions were used, one from AGK 2, or when only one earlier position was used.

Table 4.—Number of stars listed for each zone of the sky

δ\α	11h	10	9	8	7	6	5	4	3	2	1	0	23	22	21	20	19	18	17	16	15	14	13	12	Total
+80°	161	175	195	155	160	174	145	158	163	146	164	175	186	157	183	175	165	175	185	146	170	161	183	158	4015
70	218	231	305	323	339	335	320	337	271	249	253	293	346	366	296	327	306	324	296	287	250	212	200	237	6921
60	315	316	311	328	361	365	337	356	418	484	557	608	643	576	651	502	539	387	414	386	351	321	289	271	10086
50	350	386	392	457	516	585	557	605	599	906	927	927	930	1092	911	868	878	627	501	443	374	404	371	378	14984
40	415	434	497	517	614	706	841	704	744	802	860	865	975	1041	1209	1268	1090	864	702	595	514	481	418	431	17587
30	439	545	608	689	810	1025	1099	666	819	893	845	779	762	983	1154	1525	1563	1154	827	711	562	569	588	500	20115
20	474	485	556	707	888	1116	967	507	709	595	665	735	708	778	800	1287	1374	1061	890	621	529	489	519	504	17964
10	503	498	607	806	1091	1258	875	546	487	485	549	542	628	747	826	1207	1187	1068	779	656	542	519	437	467	17308
+0	550	562	700	1100	1445	1324	1045	821	652	627	675	640	585	670	764	1108	1192	1135	1023	700	627	556	516	554	19567
−0	598	642	784	1117	1315	1228	1055	764	640	608	551	546	552	639	780	1031	1065	906	546	589	662	591	580	564	18504
10	638	740	821	1113	1470	1425	953	778	601	562	585	529	626	625	743	881	1080	1104	782	591	522	684	633	617	18958
20	946	1129	1476	1829	2217	1653	1160	943	806	737	747	752	731	756	883	1114	1240	1440	1214	896	941	928	854	933	26325
30	1035	1038	1089	1179	1221	1074	922	796	661	582	580	549	679	764	831	903	900	1214	1299	1071	1035	1120	1051	1010	22603
40	671	798	948	1447	930	712	553	515	468	400	402	398	495	451	460	487	547	806	1070	1123	1064	765	778	678	16966
50	905	1090	1099	830	824	607	469	420	397	363	336	365	409	408	451	424	516	688	814	1113	1090	791	902	892	16203
60	472	446	363	348	365	289	253	239	215	229	172	201	243	252	205	209	265	327	340	377	409	423	442	438	7522
70	117	105	103	109	107	99	111	94	110	104	108	102	107	104	116	116	110	93	102	104	122	124	105	107	2579
−80	32	47	42	22	31	30	35	34	37	36	38	41	41	35	42	28	32	31	26	24	21	29	33	23	790
Total	8839	9667	10896	13076	14704	14005	11697	9283	8797	8808	9014	9047	9646	10444	11305	13460	14049	13404	11810	10433	9785	9167	8899	8762	258997

Table 5.--Symbols used for catalogs (Column 18)

and range of declination covered by each

| Code symbol	Catalog	Vol.	Equinox	Declination δ		Comparison catalog	Equinox
26A	Yale	26I	1950	+89° to	+ 85°		
AG	AGK 2	1	1950	85	80	Greenwich AC	1900
AG	AGK 2	1	1950	80	75	AGK 1, Kasan	1875
AG	AGK 2	1	1950	75	70	AGK 1, Berlin	1905
AG	AGK 2	2	1950	70	65	AGK 1, Christiania	1875
AG	AGK 2	2	1950	65	60	AGK 1, Helsingfors-Gotha	1875
27	Yale	27	1950	60	55		
26B	Yale	26II	1950	55	50		
AG	AGK 2	5	1950	50	45	AGK 1, Bonn*	1875
AG	AGK 2	6	1950	45	40	AGK 1, Bonn*	1875
AG	AGK 2	7	1950	40	35	AGK 1, Lund	1875
AG	AGK 2	8	1950 ·	35	30	AGK 1, Leiden	1875
24	Yale	24	1950	30	25		
25	Yale	25	1950	25	20		
18	Yale	18	1950	20	15		
19	Yale	19	1950	15	10		
22B	Yale	22II	1950	10	9		
22A	Yale	22I	1950	9	5		
20	Yale	20	1950	5	1		
21	Yale	21	1950	+ 1	- 2		
17	Yale	17	1950	- 2	- 6		
16	Yale	16	1950	6	10		
11	Yale	11	1950	10	14		
12A	Yale	12I	1950	14	18		
12B	Yale	12II	1950	18	20		
13A	Yale	13I	1950	20	22		
14	Yale	14	1950	22	27		
13B	Yale	13II	1950	27	30		
C7	Cape	17	1950	30	35		
C8	Cape	18	1950	35	40		
CZ	Cape Zone		1900	40	52		
C9	Cape	19	1950	52	56		
CO	Cape	20	1950	56	64		
M3	Me 3		1890	64			
M4	Me 4		1900		-89°		
F4	FK4		1950	+89°			
F3	FK3		1950				
GC	GC		1950		-89°		

*Including Mönnichmeyer's corrections.
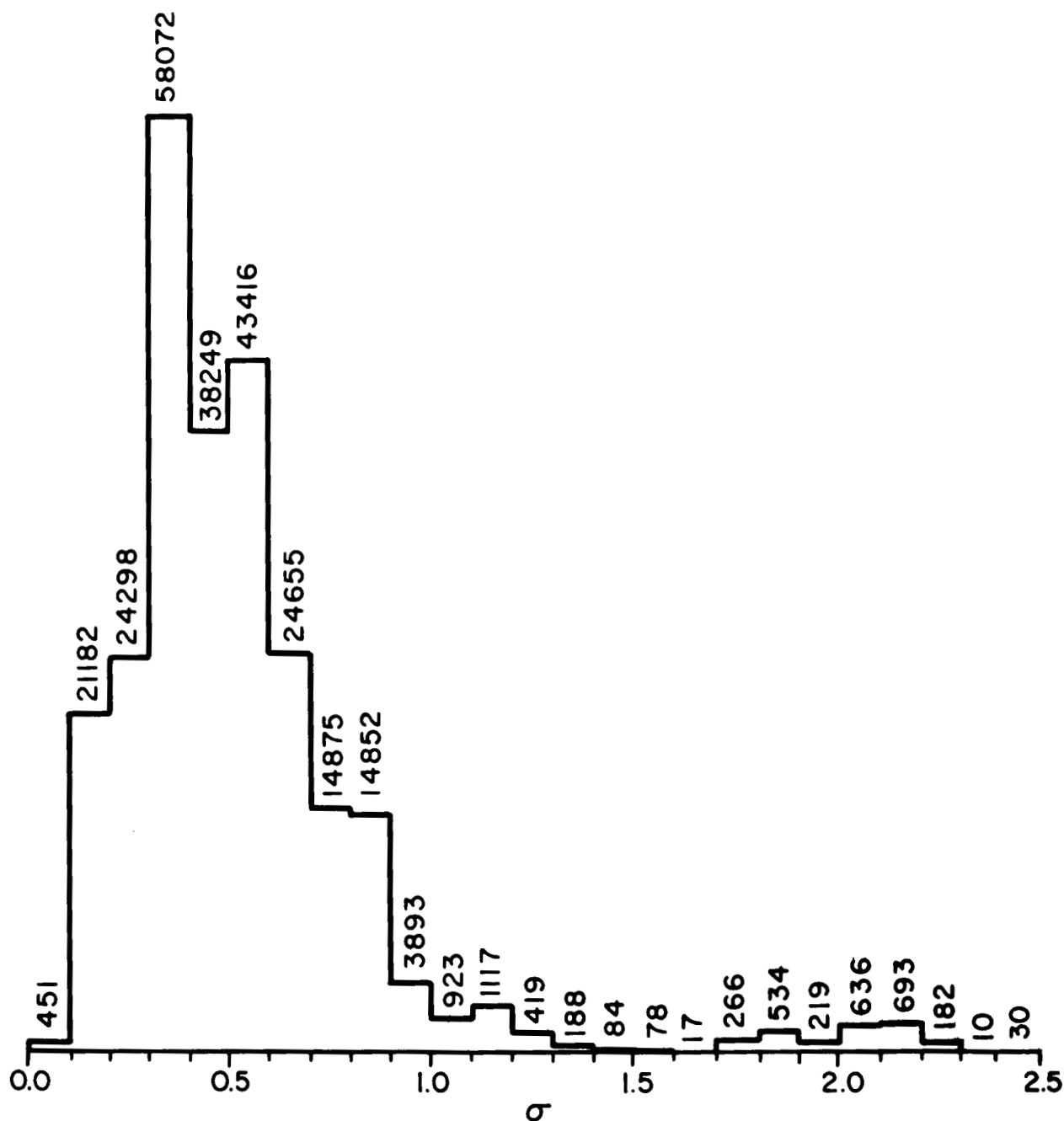
Figure 1.--Standard deviation of position at epoch 1963.5.
Abscissa = σ; number of stars is given for each
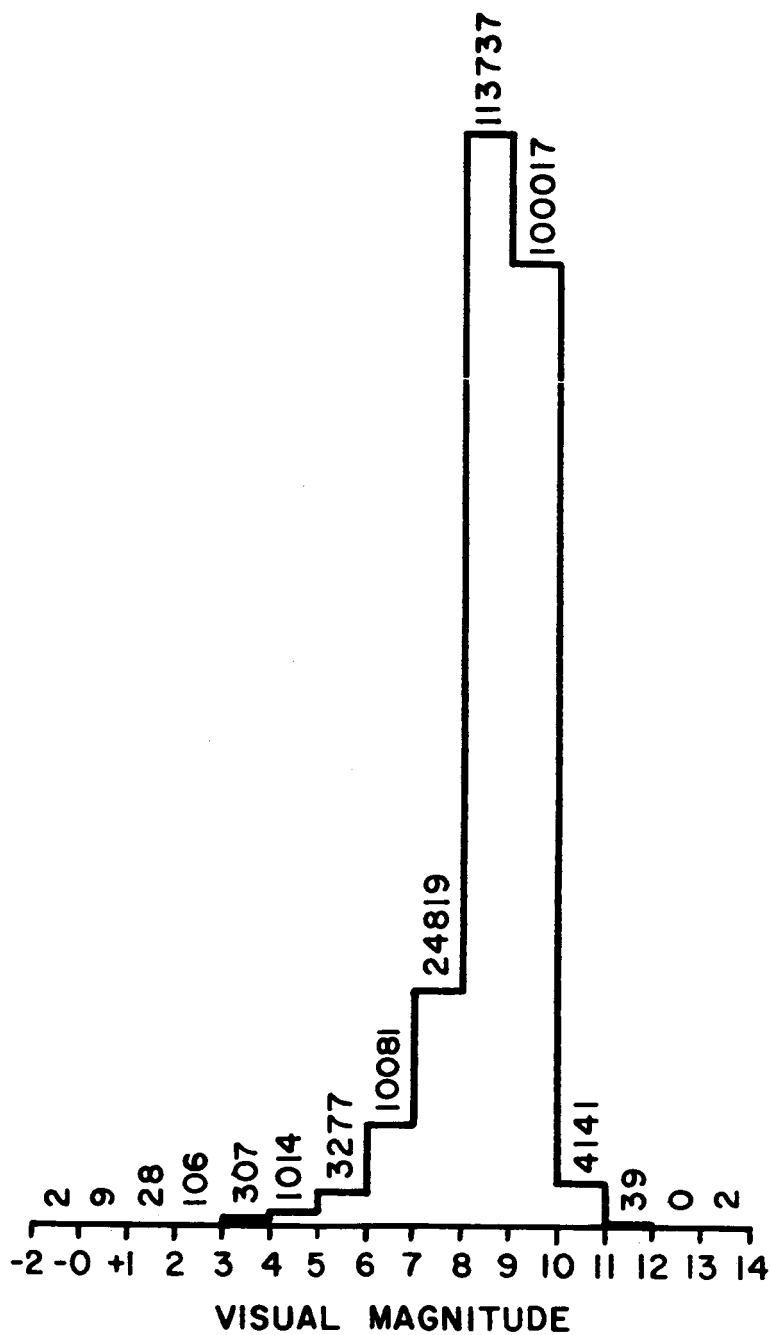interval. Average standard deviation = 0".5.

Figure 2.--Distribution of catalog stars according to
visual magnitude. Abscissa = visual magnitude;
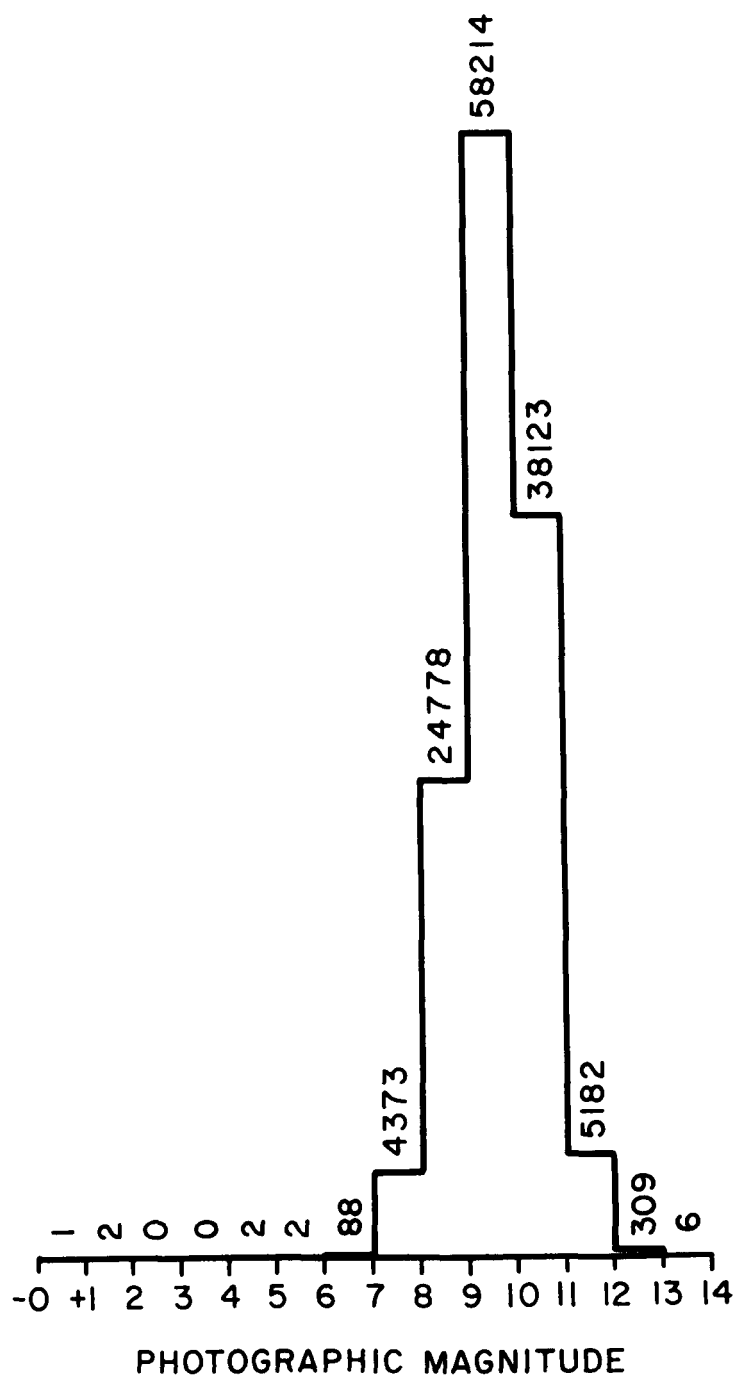number of stars is given for each interval.

Figure 3.--Distribution of catalog stars according to photo-
graphic magnitude. Abscissa = photographic magnitude;
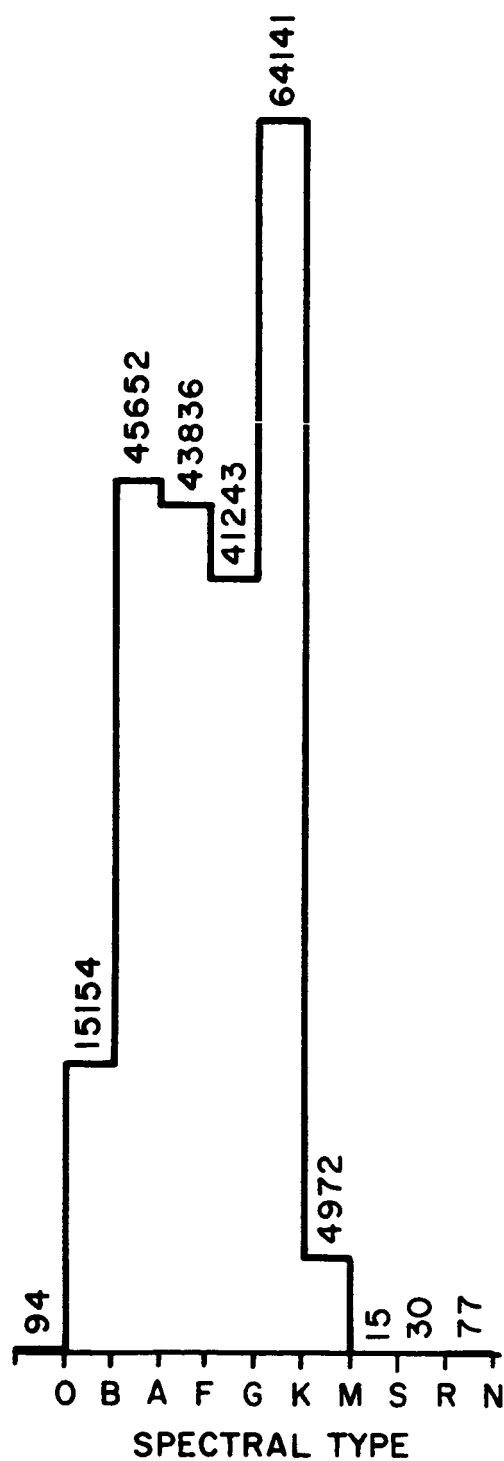number of stars is given for each interval.

Figure 4.--Distribution of catalog stars according to spectral
type. Abscissa = spectral type; number of stars is
given for each interval.